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(71) Applicants:
- Manuel, Mark
  Shelby Township, MI 48315 (US)
- Kirkum, Christopher Dean
  Mt. Clemens, MI 48043 (US)
- Racklyeft, Robert
  Brownstone, MI 48192 (US)

(72) Inventors:
- Manuel, Mark
  Shelby Township, MI 48315 (US)
- Kirkum, Christopher Dean
  Mt. Clemens, MI 48043 (US)
- Racklyeft, Robert
  Brownstone, MI 48192 (US)

(74) Representative:
Manitz, Finsterwald & Partner GbR
Postfach 31 02 20
80102 München (DE)

(54) Method and apparatus for the creation of a tool

(57) An apparatus 10 and a method 50 for the creation of a tool 40. The apparatus 10 and the method 50 allow for dynamic measurement of the tool 40 as it is being created and further allows for the use of positive feedback to increase the likelihood that the produced tool will be structurally similar to a certain model. The apparatus 10 and method 50 further allow sections of varying thicknesses to be used and provide a technique to create surfaces which further increase the likelihood that the produced tool will be structurally equivalent to a desired and modeled tool.

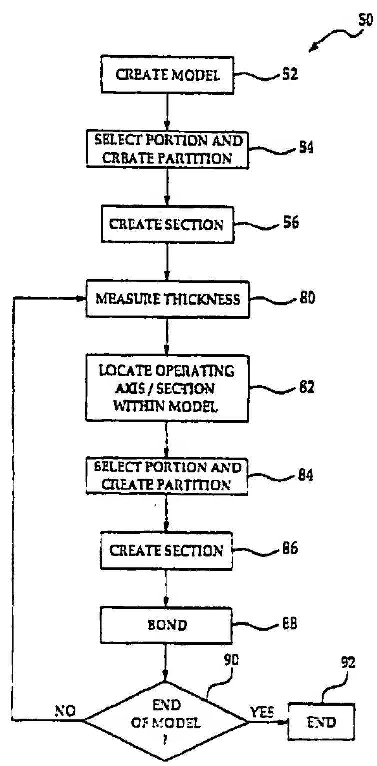

Figure 5

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then current techniques, thereby allowing a tool to be selectively, efficiently, and accurately produced.

[0012] According to a first aspect of the present invention, a method for creating a tool is provided. The method includes the steps of creating a model of the tool; creating a first partition of the model; creating a first section from the first partition; measuring the section; using the measurement to create a second partition of the model; creating a second section from the second partition; and attaching the second section to the first section, thereby forming a tool.

[0013] According to a second aspect of the present invention, a method for creating a tool is provided. The method includes the steps of creating a model of the tool; creating a first partition of the model; creating a first section having a first width by use of the first partition of the model; creating a second partition of the model; creating a second section having a second width by use of the second partition of the model; and attaching the second section to the first section, thereby forming the tool.

[0014] According to a third aspect of the present invention, a method for forming a tool is provided. The method includes the steps of creating a model of the tool; creating a plurality of partitions from the model, each of the plurality of partitions having respective first and second ends of a certain respective height; and creating a section for each of the plurality of partitions, each section having first and second ends and each of the first and second ends having a substantially similar and respective height which is equal to the height of the first end of the partition to which that section pertains only when the height of the first end of the partition to which that section pertains is larger than or equal to the height of the second end of the partition to which that section pertains, and wherein each section has a surface which resides between the respective first and second ends.

[0015] According to a fourth aspect of the present invention, an apparatus is provided which selectively forms a tool. The apparatus includes a tool model forming portion; a press which is coupled to the tool model forming portion; a section forming portion which is coupled to the tool model forming portion and to the press and which forms sections by use of the tool model and which selectively stacks the formed sections within the press; and a measurement portion which measures the thickness of the stacked sections and which generates a signal, based on the thickness measurement, and which communicates the signal to the model forming portion.

[0016] These and other features, aspects, and advantages of the present invention will become apparent by a review of the following detailed description of the preferred embodiment of the invention and by reference to the following drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

Figure 1 is an exploded perspective view of a tool which is made in accordance with the teachings of the preferred embodiment of the invention and further illustrating a partition of the tool which is used to form a section in the tool formation process of the preferred embodiment of the invention;

Figure 2 is block diagram of a tool creation and/or forming apparatus which is made in accordance with the teachings of the preferred embodiment of the invention and which may be used to create the tool which is shown in Figure 1;

Figure 3 is a perspective view of a section which is created by the use of the tool partition which is shown in Figure 1 and by the tool creation apparatus which is shown in Figure 2;

Figure 4 is a side view of the section which is shown in Figure 3; and

Figure 5 is a flowchart including a sequence of operational steps performed by the apparatus which is shown in Figure 2 and cooperatively forming the tool forming methodology of the preferred embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT OF THE INVENTION

[0018] Referring now to Figure 2, there is shown a tool creation and/or forming apparatus 10 which is made in accordance with the teachings of the preferred embodiment of the invention. As shown, tool creation apparatus 10 includes a computer or processor 12 which ia operable under stored program control and which selectively creates and/or receives a computer aided design or a substantially "similar type of model" or intangible manifestation of a tool which is to be created. Such a model typically has a three dimensional data format, including but not limited to data which specifies the surface features and contours necessary to allow the formed tool to produce a desired part or product. In one non-limiting embodiment, computer or processor 12 comprises a commercially available computer, and the created and/or received model may form a three dimensional and relatively accurate picture of the tool.

[0019] Tool creation apparatus 10 further includes a laser cutter 14 which is controllably and communicatively coupled to the model creator and processor 12 and a material provider 16 which is communicatively and controllably coupled to the laser cutter 14 and to the model creator and processor 12. In one-non limiting embodiment of the invention, material provider 16 provides and transports sheets of material having a certain desired and/or specified thickness and height to the laser cutter 14. Hence, in this non-limiting embodiment of the invention, section provider 16 comprises a store of sheets of

model creator and processor 12 along the edge 60. Similarly, various points 72 are defined along the edge 58. Each point 72 uniquely corresponds with or to (e.g., is substantially co-linear to) one of the points 70. The height or the "z-dimension" value for each pair of corresponding points 70, 72 is compared and the point 70, 72 having the lowest height is "modified" by having its height increased to equal the height of the other point 70, 72. In this manner, each pair of corresponding points 70, 72 has a substantially identical height which is equal to the largest height associated with or provided by the points 70, 72, and these modified points 70, 72 cooperatively define modified edges 58, 60. In one non-limiting embodiment, there is substantially no space between points 70 and substantially no space between points 72. The points 70, 72 are then respectively used to define the height of edges 64, 62. That is, the two modified edges 58, 60 (e.g., the modified points 70, 72) are overlayed to form a two dimensional edge and edges 64, 62 are made to be substantially similar to this two dimensional edge. In some alternate embodiment, the foregoing procedure is modified by causing the opposing edges 62, 64, at each pair of corresponding points 72, 70, to have a height which is substantially identical to the greatest height of any surface or portion of the model which resides between these pairs of corresponding points. That is, each pair of corresponding points 70, 72 is made to have a substantially identical height which is equal to the greatest height of any surface which resides between them and is co-linear to them. This alternative procedure is used when partitions of relatively large widths are used. In yet another non-limiting embodiment, each pair of corresponding points 70, 72 is made to have a height which is the greatest of the height of any of the two corresponding points 70, 72 and any surface which is between and co-linear to them. These "modified" points 70, 72 then form, within processor 12, a two dimensional line which become the cutting path for the laser cutter 14, The foregoing "modification" allows for the inclusion of surface counters necessary to allow the formed tool to perform the desired function and yet allows the tool to be rapidly formed.

[0028] The laser cutter 14 then forms the provided material in the manner, thereby creating section 66 from the partition 51 (e.g., surface 68 may be typically formed by a subsequent operation which may be accomplished by a conventional machine). Step 80 then follows step 56 and, in this step 80, the thickness measurer 24 measures the thickness or "x direction value" of the formed section 66 and provides the measurement to the model creator and processor 12. Step 82 follows step 80 and, in this step 82, the model creator and processor 12 uses the thickness measurement value to determine the amount of the model which has been replicated. That is, the model creator and processor 12 compares and uses the measured "x" direction value to fix a location within the model with which to create a new cross sectional partition within (e.g., the apparatus 10 will not attempt to replicate an already existing portion of the model). In this manner, structural variances within the provided material as well as other variances associated with such items as the bonding material which may increase the thickness of the created structure may be accounted for (e.g., the processor 12 may dynamically become aware of the fact that a larger amount of the model has been physically created and dynamically adjust to this situation by moving the site of the next partition to be created). Hence, these thickness measurement signals comprise dynamic positive feedback signals which allow tools to be rapidly and accurately made. This procedure also allows for the use of sections with varying thicknesses (e.g., the processor and model creator 12 may dynamically adjust and specify substantially any thickness for the created partition and section), thereby reducing production cost, and provides a "quick" or timely warning of inaccuracies with the produced structure.. The positive feedback signal, in one non-limiting embodiment, is provided after each section is made, thereby providing timely notification of undesired large variances between the thickness of the created structure and the amount of the model which may desired to be replicated by this structure.

[0029] Step 84 follows step 82 and, in this step 84, another partition of the model may be taken in substantially the same manner as was previously delineated. Step 86 follows step 84 and, in this step, a section is created for this partition in the previously delineated manner. The newly created section is transported to the press 20, by portion 18, and is bonded to the previously deposited section. Step 90 follows step 88 and, in this step, the model creator and processor 12 determines whether the model has been completed. If the model has not been completed, step 90 is followed by step 80 in which the thickness of the bonded section is measured. This "thickness" feedback allows the processor 12 to dynamically learn of the amount the model that has been constructed and to compare the measured value with the theoretical or intangible values contained within the processor 12. Such comparison may cause processor 12 to determine that the tool has been incorrectly made and allow the processor 12 to quickly warn the user and/or recommend other corrective actions. Partitions and sections are created and selectively bonded by the previously described steps 80, 82, 84, 86, and 88, to the then existing structure until the tool is made. The methodology 50 is ended at step 92.

[0030] It should be appreciated that the invention is not limited to the exact construction or method which has been illustrated and discussed above, but that various changes and modifications may be made without departing from the spirit and the scope of the invention as is more fully delineated in the following claims.

16. The apparatus of claim 14 wherein said section forming portion comprises a laser cutter; a section transporter: and material provider.

17. The apparatus of claim 16 further comprising a bonding provider which is coupled to said press.

18. The apparatus of claim 17 wherein said bonding provider comprises a bonding material source; and an applicator.

19. The apparatus of claim 18 wherein said applicator comprises a robot.

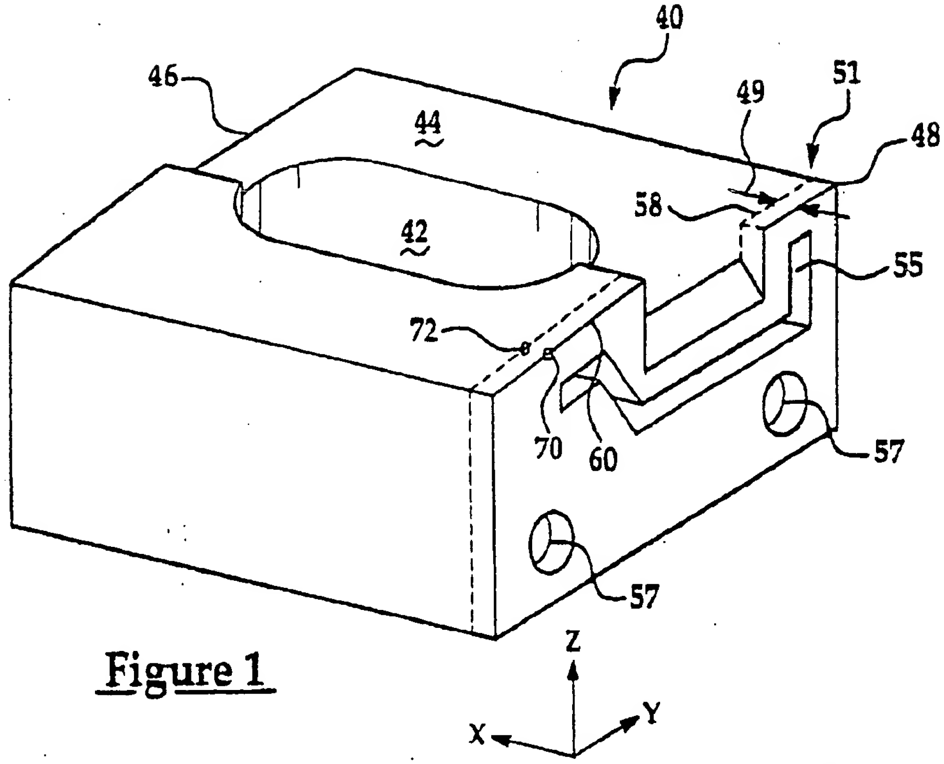

Figure 1

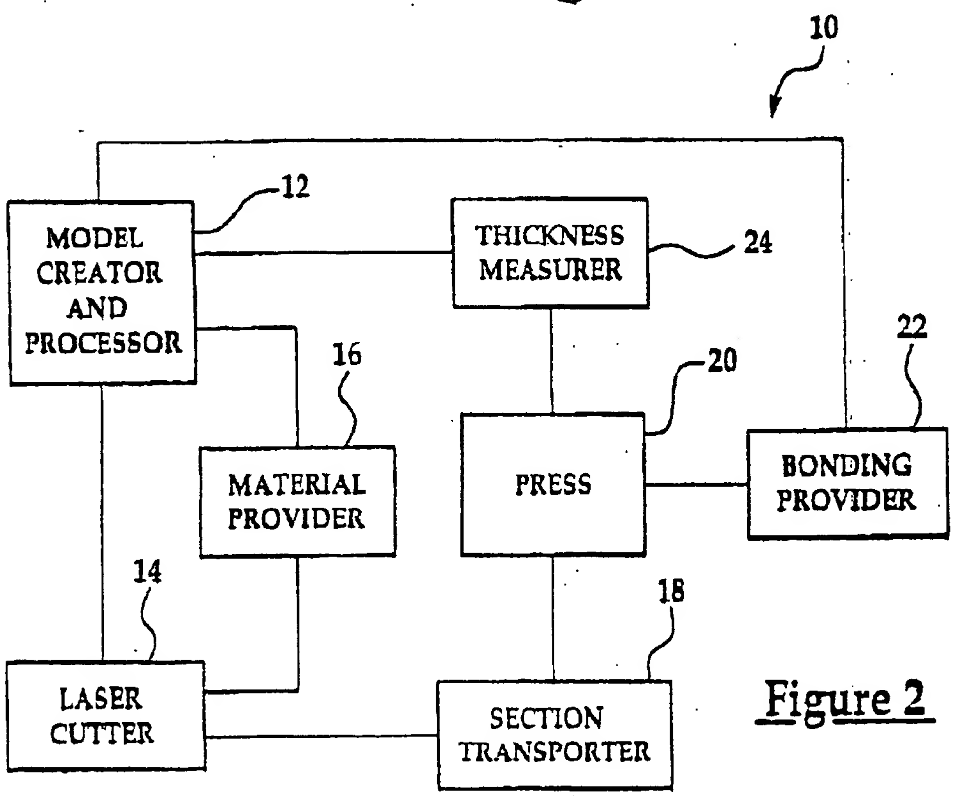

Figure 2

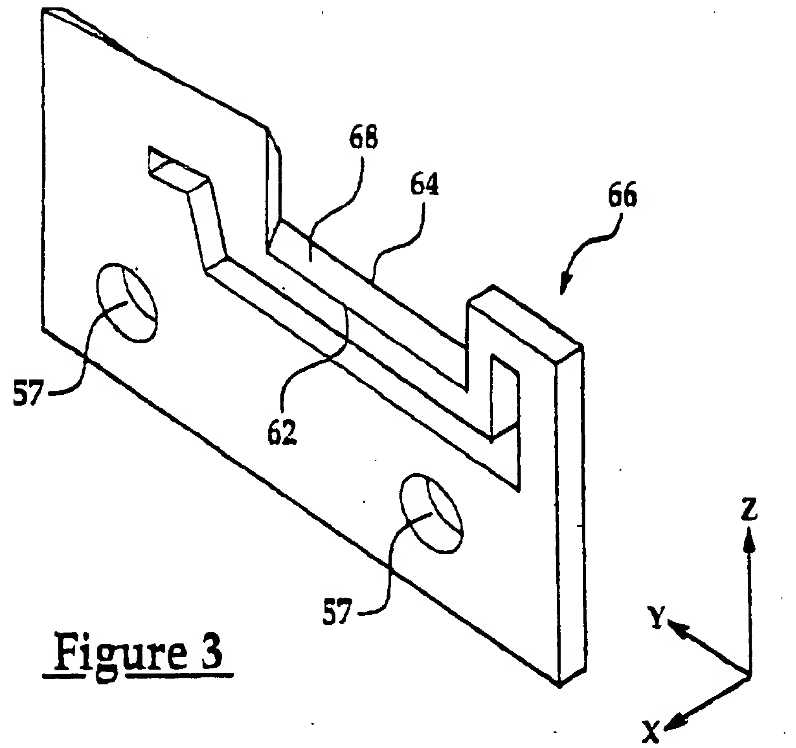

Figure 3

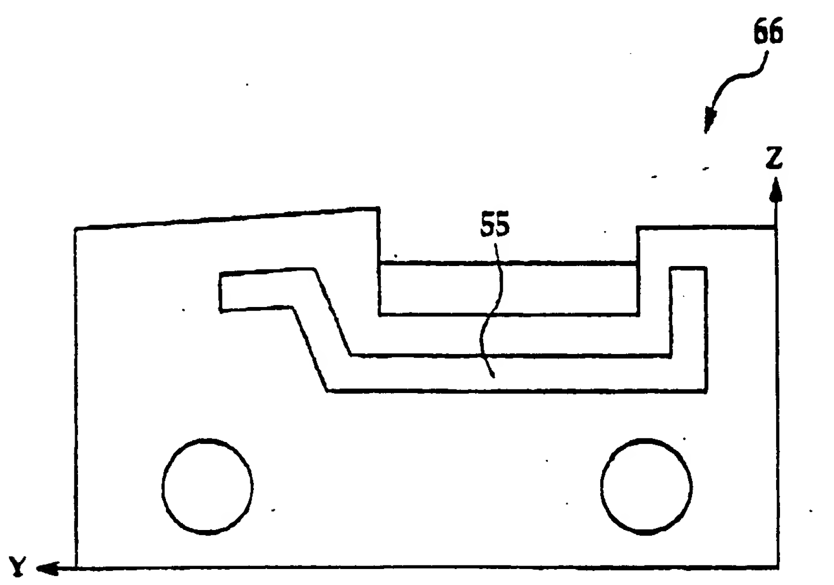

Figure 4

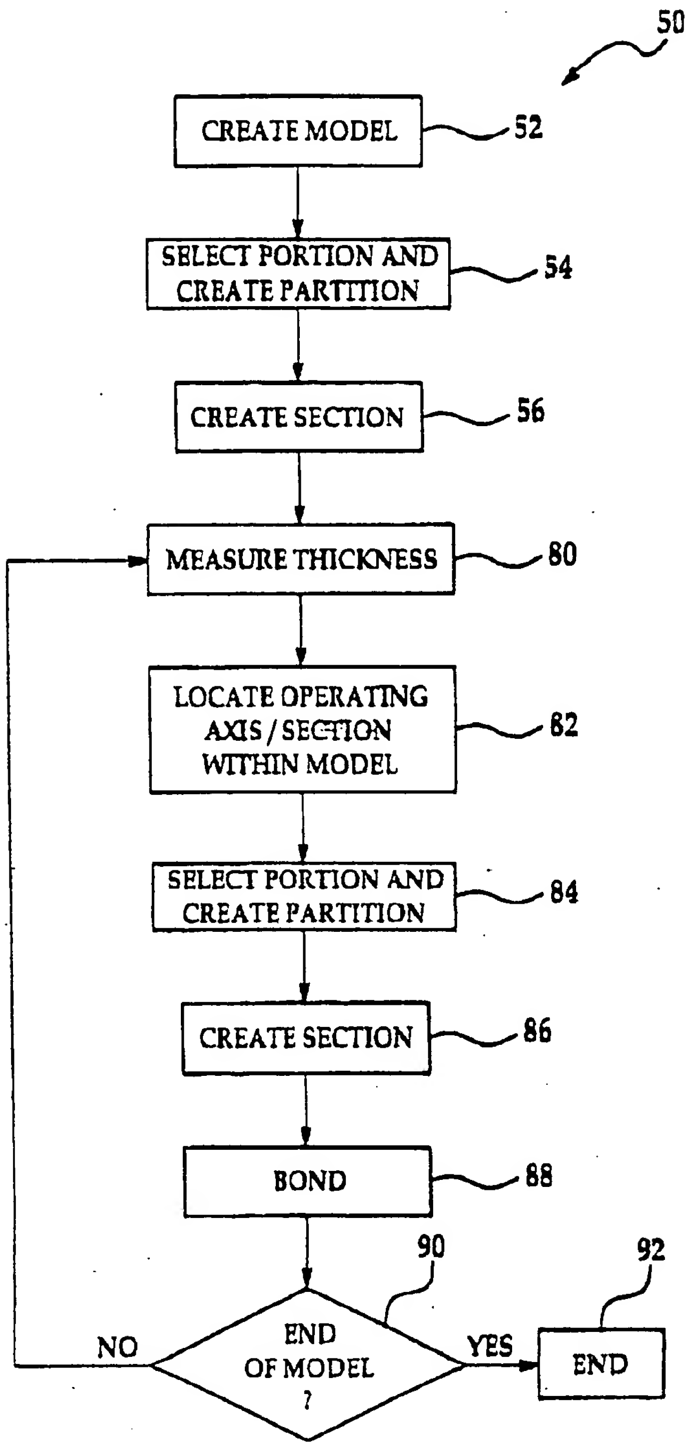
50
CREATE MODEL
52
SELECT PORTION AND CREATE PARTITION
54
CREATE SECTION
56
MEASURE THICKNESS
80
LOCATE OPERATING AXIS / SECTION WITHIN MODEL
82
SELECT PORTION AND CREATE PARTITION
84
CREATE SECTION
86
BOND
88
90
END OF MODEL ?
NO
YES
92
END

Figure 5